

09/881,408

In the Claims

Claims 1-19, 56-58, and 62 are pending in the application with claims 1 and 8 amended herein and claims 52, 60, and 61 cancelled herein.

1. (currently amended) A method of forming a dielectric layer comprising:

providing a substrate comprising a silicon-containing surface;

forming a first metal-containing ~~dielectric layer consisting of metal oxide~~ over the surface, all the metal of the first ~~dielectric~~ layer consisting of at least one element selected from Group IVB of the periodic table;

forming a second metal-containing ~~dielectric layer consisting of metal oxide~~ on and in contact with the first metal-containing ~~dielectric~~ layer, all the metal of the second ~~dielectric~~ layer consisting of at least one element selected from Group IIIB of the periodic table; [[and]]

exposing the first layer and the second layer to an oxygen comprising atmosphere and heating the first layer and the second layer to a temperature effective to form a first metal-containing dielectric layer consisting of metal oxide and a second metal-containing dielectric layer consisting of metal oxide; and

including the first and second metal-containing dielectric layers in an integrated circuit device.

2. (previously presented) The method of Claim 1, wherein the metal of the first metal-containing dielectric layer consists of hafnium.

09/881,408

~~17~~
~~3.~~ (previously presented) A method of forming a dielectric layer comprising:

providing a substrate comprising a silicon-containing surface;

forming a layer of silicon dioxide overlying at least one portion of the surface;

forming a metal layer over the layer of silicon dioxide;

heating the metal layer and layer of silicon dioxide to a temperature of from about 200°C to less than 400°C and combining metal of the metal layer with oxygen of the silicon dioxide layer to form a metal oxide dielectric material comprised by a first metal-containing dielectric layer over the surface, all the metal of the first dielectric layer consisting of at least one element selected from Group IVB of the periodic table; and

forming a second metal-containing dielectric layer on and in contact with the first metal-containing dielectric layer, all the metal of the second dielectric layer consisting of at least one element selected from Group IIIB of the periodic table.

~~18~~
~~4.~~ (previously presented) The method of Claim ~~3~~¹⁷, wherein the metal layer comprises hafnium.

~~19~~
~~5.~~ (original) The method of Claim ~~4~~¹⁸, wherein the combining comprises providing conditions effective for the hafnium of the metal layer to chemically reduce the silicon dioxide layer.

09/881,408

~~3~~
~~8.~~ (previously presented) The method of Claim 1, where the metal of the second metal-containing dielectric layer consists of one element selected from Group IIIB of the periodic table.

~~4~~
~~7.~~ (previously presented) The method of Claim 1, where the metal of the second metal-containing dielectric layer consists of lanthanum.

~~5~~
~~8.~~ (currently amended) The method of Claim 1, wherein the first metal-containing layer is a hafnium-containing layer and the second metal-containing layer is a lanthanum-containing layer where the forming of the first metal-containing dielectric layer and the forming of second metal-containing dielectric layer comprise:

~~forming a hafnium-containing layer;~~

~~forming a lanthanum-containing layer over the hafnium-containing layer; and~~

~~exposing the hafnium-containing layer and the lanthanum-containing layer to an oxygen comprising atmosphere and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer.~~

~~6~~
~~8.~~ (original) The method of Claim ~~5~~
~~8.~~, where forming the hafnium-containing layer and the lanthanum-containing layer comprises physical vapor deposition.

09/881,408

~~7~~
~~10.~~ (previously presented) The method of Claim ~~8~~⁵, where the exposing comprises ion bombardment of the first hafnium-containing layer and the lanthanum-containing layer using an ion bombardment energy of about 10 electron volts (eV) or less.

~~8~~
~~11.~~ (original) The method of Claim ~~10~~⁷ where the heating comprises heating to a temperature from about 200°C to about 400 C during the ion bombardment.

~~9~~
~~12.~~ (original) The method of Claim ~~8~~⁵, where the exposing comprises positioning the substrate within a reaction chamber and exposing the hafnium-containing layer and the lanthanum-containing layer to oxygen radicals within the reaction chamber.

~~10~~
~~13.~~ (original) The method of Claim ~~8~~⁵, where:
the forming the hafnium-containing dielectric layer comprises depositing hafnium to a thickness less than or equal to about 5 nanometer (nm); and

the forming the lanthanum-containing dielectric layer comprises depositing lanthanum to a thickness less than or equal to about 5 nm.

~~11~~
~~14.~~ (original) The method of Claim ~~13~~¹⁰ comprising a ratio of the hafnium thickness to the lanthanum thickness of from about 1 to 3 to about 1 to 4.

09/091,408

~~12~~~~15.~~ (original) The method of Claim ~~5~~, where;

the forming the hafnium-containing dielectric layer comprises forming a layer containing hafnium to a thickness of about 1 nm;

the forming the lanthanum-containing dielectric layer comprises forming a layer containing lanthanum to a thickness no greater than about 5 nm; and

wherein a ratio of thicknesses of the hafnium-containing layer to the lanthanum-containing layer is from about 1 to 3 to about 1 to 4.

~~13~~

~~16.~~ (original) The method of Claim 1, where the forming of the first and second metal-containing dielectric layers comprises physical vapor deposition.

~~14~~

~~17.~~ (original) The method of Claim ~~13~~, where physical vapor deposition comprises electron beam evaporation.

~~15~~

~~18.~~ (original) The method of Claim 1, where forming the first metal-containing dielectric layer and the second metal-containing dielectric layer comprises forming the layers to have respective thicknesses having a ratio of from about 4:1 to about 1:4.

~~16~~

~~19.~~ (original) The method of Claim 1, where the first metal-containing dielectric layer consists of hafnium oxide and the second metal-containing dielectric layer consists of lanthanum oxide.

Claims 20-51 (cancelled).

52. (cancelled).

08/881,408

Claims 53-55 (cancelled)

~~21~~
56. (previously presented) A method of forming a dielectric layer comprising:

providing a substrate comprising a silicon-containing surface;
forming a layer of silicon dioxide overlying at least one portion of the surface;
forming a hafnium-containing layer over the layer of silicon dioxide;
combining hafnium of the hafnium-containing layer with oxygen of the silicon dioxide layer to form a hafnium oxide over the surface;
forming a lanthanum-containing layer over the hafnium-containing layer; and
exposing the hafnium-containing layer and the lanthanum-containing layer to an oxygen comprising atmosphere by ion bombardment using an energy of about 10 electron volts (eV) or less, and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer.

~~22~~
57. (previously presented) The method of Claim ~~56~~²¹ where the heating comprises heating to a temperature from about 200 C to about 400 C during the ion bombardment.

09/881,408

~~23~~

~~58.~~ (previously presented) A method of forming a dielectric layer comprising:

providing a substrate comprising a silicon-containing surface;

forming a layer of silicon dioxide overlying at least one portion of the surface;

forming a hafnium-containing layer over the layer of silicon dioxide;

combining hafnium of the hafnium-containing layer with oxygen of the silicon dioxide layer to form a hafnium oxide over the surface;

forming a lanthanum-containing layer over the hafnium-containing layer; and

positioning the substrate within a reaction chamber and exposing the hafnium-containing layer and the lanthanum-containing layer to oxygen radicals within the reaction chamber and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer.

Claim 59 (cancelled).

60. (cancelled).

61. (cancelled).

~~20~~

~~62.~~ (previously presented) The method of claim ~~3~~¹⁷ wherein the second dielectric layer consists of metal oxide.